HAITI AGROFORESTRY RESEARCH PROJECT

SOUTH-EAST CONSORTIUM FOR INTERNATIONAL DEVELOPMENT/

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Short-Term Seedling Field Survival and Growth as Influenced by Container Type and Potting Mix

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Summary

This investigation tested the field performance of planting stock types used in the AOP. Field growth and survival of five species (chene, kapab, cassia, neem, and ced) were measured. Four container types (Winstrips, standard Rootrainers, Rootrainer Deep 5s, and Sacks) and three potting mixes (Gromix, Haiti mix, and Neg mix) were tested, as were direct seeding and stump planting for some species. Planting stock types were planted in a completely random design on both a good site and a poor site.

Three months after outplanting, the best performers were seedlings from Sacks. Out of all possible post-planting measurements, Sack seedlings performed better than seedlings from other containers 42% of the time, and never performed more poorly than other seedlings. Differences were not common among the other three container types, and followed no standard pattern when they occurred. In particular, although Rootrainer seedlings tended to be smaller than those from Deep 5s, differences between Rootrainers and Deep 5s were not biologically important. Potting mix had little effect on three-month results, but occasionally appeared to interact strongly with container type.

Direct seeding was not successful in this study, but should be tested in a setting that more closely resembles actual operations. Neem and cassia stumps survived adequately and grew well, however. They tended to not perform as well as containerized seedlings, but their performance was not different from seedlings produced in rigid containers in most cases.

Rezimé Kréyol

Esperyans sa-a te fèt pou èseyé kèk teknik pou fè ti pyebwa nan developman jaden. Nou té meziré ki jan senk espès (nim, kasya, kapab, chèn, ak sèd) té chapé. Nou té èseyé kat kalité vèso (Winstrip, Woutrenè pa fon, Woutrenè fon, ak Saché plastik) ak twa kalité miks (Gromiks, Ayiti miks, ak Neg miks). Ak kèk èspès nou té simen Semans dirèk ou nou tè plantè Chouk. Nou tè fé ésayaj ni nan jaden gra ni nan jaden meg.

Twa mwa pi ta nou wè pyebwa ki té soti nan Saché plastik té chapé pi byen pasé tout lot pyebwa ki té planté yo. Nou pat jwenn ampil difèrans nan ti pyebwa ki té soti nan lot vèso yo. Pyebwa ki té soti nan Woutrenè pa fon té soti pi piti pasé sa ki té soti nan Woutrenè fon, men pat gen ampil difèrens. Miks la pat fè ampil èfè sou twa mwa yo, men gen lè sa té depen sou kalité vèso ki té sevi avèk li.

Simen Semans dirèk pat maché byen, men nou dwé éseyé li nan yon ésperyans ki pi samblé jaden peyizan. Ni Chouk nim ni Chouk kasya té byen pousé men pa si byen pyebwa ki soti nan Woutrenè è Winstrip. Pa gen gwo difèrans ent ti pyebwa ki té vini nan Chouk ou sak soti nan Woutrenè ou Winstrip.

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ODH and Steve Gronski, as paid participants, provided the containerized planting stock and the Cazeau site.

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INTRODUCTION

Tree seedling production for the Haitian Agroforestry Outreach Program (AOP) traditionally has been in containers. This tradition is understandable, since most foresters are taught that production of new forests using containerized planting stock requires less technical expertise than does reforestation from bare-root stock (Daniel et al. 1979), and most workers find better survival with containerized seedlings than with bare-root seedlings when both are outplanted into a stressful, degraded environment (Tinus and McDonald 1979). Although different containers and container mixes have been used in the AOP, and many strong opinions exist about their relative merits, growth and survival rate data from side-by-side comparisons are hard to find. Workers in the AOP are interested in seeing which container performs best in the field, and are especially interested in comparing containers of different depths. Many people feel a longer root plug helps a seedling survive better, especially on dry sites where it allows access to subsurface moisture. Others think the extra depth creates irrigation problems in the nursery, thus hindering root development and field survival.

Since the infrastructure of a tree-planting program and the concomitant expertise now exist in Haiti, other planting stock options may be possible. Possibly the most obvious option is direct seeding. This regeneration method has several advantages. One advantage is the ability of farmers to readily understand it

because it is an extension of crop planting, a technology familiar to them. Another is the hardiness of seed relative to seedlings: seed can be transported farther and stored longer before planting. Disadvantages of this method include the need for more seed to produce the same number of seedlings that would be produced in a nursery, the need for more careful weeding than is necessary with seedlings, and susceptability of seed and newly-emerged seedlings to drought and predation by rodents.

Another option is production of bare-root planting stock. A problem in Haiti with outplanting traditional bare-root stock is seedling moisture stress. Such stress is caused by root damage at lifting and by the relatively large shoot in a hot environment. This problem might be overcome by mechanically increasing the root-shoot ratio. Roots and tops can be trimmed from the seedlings while still in the nursery bed, and the resulting "stumps" outplanted. Advantages of this method include the possible production of more seedlings in the same size nursery, and the ability to transport many more individual seedlings than would be possible with the same weight of containerized stock. The biggest potential disadvantage is not technical, but social: farmers might resist a new technique, at least until they see that it works.

This study had as its objective to determine the differences in seedling growth and survival as influenced by direct seeding, stump planting, and container type and potting mix for several non-leguminous tree species commonly planted in the AOP. This

paper presents survival and growth results for the first three months after outplanting.

METHODS

Containerized stock for this study was produced at the Operation Double Harvest nursery in Cazeau. A companion nursery study compared effects of containers and mixes on seedling development in the nursery (Reid 1989). The design of that study produced 12 distinct treatment combinations. Based on the outcome of that study, CARE, PADF, and SECID decided which of those combinations to outplant as part of this survival study. Species tested in this outplanting study were neem (Azadirachta indica A.Juss), cassia (Cassia siamea Lam.), kapab (Colubrina arborescens (Mill.) Sarg.), chene (Catalpa longissima (Jacq.) Sims), and ced (Cedrela odorata L.).

Stumps tested here were produced at CARE nurseries in northwest Haiti. Seed was sown directly onto the outplanting site as close as possible to the time the seedlings were planted. Thus, for each of the five tree species used, as many as 12 production methods (selected containerized combinations plus the two non-containerized methods) or as few as eight production methods (selected containerized combinations) were compared for their effects on growth and survival. The combinations used for each species are listed in Table 1.

This study was outplanted onto two sites. These sites were a "good" one at the ODH facility in Cazeau, and a "poor" one at

the PADF demonstration area at Mirebalais. Because stumps and containerized stock were produced in different locations, and since soils within a site in Haiti typically vary randomly, the blocking in the nursery study was not carried over to the field study. Instead, the planting stock x species combinations were planted in a completely random design.

The Mirebalais site was cleared of brush by hand labor the week of 8 May. Twelve seedlings from each container x mix combination were outplanted onto the site on 17 May. Stumps of 19 neem and 17 cassia also were planted, and treated (Josiah 1989) Seeds were sown at 12 spots for neem, 12 for cassia, and 13 for kapab. Stumps and Seeds were planted on 5 June. Seeds received minimum water at planting. According to the nursery workers there, very little rain fell at the site during May and June. Nevertheless, weediness has been a minor problem, and the site was weeded 20 June, 18 August, and 12 October. The one-month survival check was made on 16 June, and three-month measurements were made on 31 August.

The Cazeau site was disked with a tractor the week before it was planted, and 20 seedlings from each container x mix combination were outplanted there. Containerized stock was planted 27 and 29 May 1989, and Stumps and Seeds a week later. Twenty-two neem and 24 cassia Stumps were planted, and Seeds which had received proper pre-germination treatment (Josiah 1989) were sown at 25 spots for neem, 25 for cassia, and 27 for kapab. Seeds were watered at planting and every other day for two weeks.

About ten days after the seedlings were planted, a water main burst near the site. The site did not flood, but the ground for about half the planted area was saturated. The one-month survival check was made on 28 June, and three-month measurements on 5 and 6 September.

Initial variables measured include shoot length (height) and root collar diameter (caliper). Strictly speaking, these are pre-planting measurements, since they were measured before the plants had a chance to respond to the sites. Post-planting measurements were survival tallies, three-month height and caliper, and growth for the first three months. Growth and survival will be monitored during the first year and checked annually afterwards, assuming records are passed on from the AOP to the AOP II. Treatment differences in growth and survival were detected by analysis of variance. Protection against Type I errors was set at five percent, or $\alpha=0.05$.

Treatment means were separated by contrast statements when an overall treatment effect was found (Snedecor and Cochran 1967). This mean separation technique can also be called, with minor differences in execution, linear contrasts, non-orthogonal contrasts, or single-degree-of-freedom sums-of-squares. Using this technique, any single treatment mean can be compared to any other. Additionally, means of similar treatments can be grouped and be compared to other grouped means. In this present study, mixes were grouped and compared to other mixes, and containers grouped and compared to other containers. The differences found

among the means were easily presented (Tables 2 - 11) for some measurements; that is, differences could be indicated by a letter suffixed to the value, with values followed by the same letter not being different. In other cases, however, as when both mixes and containers had effects, differences were too intertwined to be indicated this way, and they could not be clearly presented in the tables. Treatment differences for those measurements are described in the Results section.

At the request of PADF, the trees growing at Mirebalais underwent additional analysis. A person visiting that site notices that survival is much better on one portion than it is on the other. Based on this survival, the trees growing on the poor portion of the site were separated out and the nursery treatment effects analyzed. No new information was gained by this additional analysis; in most cases, the sample size was too small to allow differences to be detected. So few ced survived at Mirebalais that separation itself was impossible. Means and analysis of the other four species growing on the poor site are presented in the Appendix.

RESULTS

Neem at Cazeau -

Treatment effects on initial height and survival are found in Table 2. Nursery treatment did not cause differences in three-month height or height growth (Table 3).

Initial heights were not different between seedlings growing

in Gromix and Haiti mix nor between those in Rootrainers and Winstrips, but all other groupings produced statistical differences. Initial calipers were not different between Gromix and Haiti mix seedlings, nor among seedlings in any of the rigid containers. At one month, Seeds had survived least well, Stumps next, and no survival differences were found among container or mix treatments. At three months, enough individuals from containers had died that Stump survival was no longer different from survival for containerized seedlings.

Seedlings originating from field-planted seed grew well when they survived, but had not grown as much as outplanted seedlings had grown at the three-month measurement (Table 3). For root collar diameter at three months, Sack seedlings and Stumps were largest, followed by seedlings from Deep 5s, Rootrainers, and Winstrips. Deep 5 seedlings were statistically larger in caliper than Winstrip seedlings. Root collar diameter growth followed a slightly different pattern. Sack seedlings grew significantly more than seedlings from Rootrainers or Winstrips. None of the mixes or rigid containers produced seedlings which grew differently, but Stumps grew very little and less than any other seedling.

Neem at Mirebalais -

Nursery treatment affected all measurements of neem at Mirebalais, including survival. The initial measurements differed with practically every nursery treatment (Table 2). Initial heights were greater for Gromix than for Neg mix

seedlings, and height differed among all Seed, Stump, and container combinations. The nursery effect on root collar diameter was similar, except no differences were found among the rigid containers.

The effect of planting stock type on survival was evident only for Seeds and Stumps. No seedlings from direct seeding were alive at one month, and the Seed treatment was dropped from further analysis. Stumps did not survive as well as containerized seedlings either time survival was checked. Note that most neem stumps at Mirebalais appeared dead at one month, but several sprouted after that. Mix had no effect on survival or on three-month measurements.

Sacks again affected three-month measurements and growth (Table 3). Sack seedlings were taller and grew more in height than seedlings from other treatments, which did not differ from one another. These same differences among Sacks and the other containerized treatments were seen with root collar diameter. In addition, since Stumps grew least of all the treatments, Sack seedling caliper was as large as that of Stumps at three months. Root collar diameter of seedlings from Deep 5s were also significantly larger than those from Winstrips, primarily because of Winstrip's response to Neg mix.

Cassia at Cazeau -

Treatment results for cassia are given in Tables 4 and 5. Differences in initial height were found among all container and mix treatments other than Rootrainers and Deep 5s. Initial stump

height differed from Sacks and Winstrips, but not from the bookplanters. Initial root collar diameter was greatest for Stumps and significantly less for Sack seedlings. Rigid containers produced smaller diameter seedlings, which differed from each other only when seedlings from Winstrips were significantly larger than those from Deep 5s. Seedlings from Neg mix had statistically smaller initial calipers than those from Haiti mix.

Except for seedlings produced from seed, stock type did not affect one-month survival. At three months, however, seedlings produced in Neg mix had survived better than those produced in Gromix, and those produced in Sacks survived better than those produced in Deep 5s. Three-month survival of Deep 5 seedlings was less than survival of those from Winstrips, and Stump survival was not different from containerized seedling survival.

Nursery-produced differences began to decrease by the three-month measurements. No mix effects were found then. Seedlings produced in Sacks were taller and larger in diameter than all others, and had grown the most since outplanting. Stump height growth was not different from that of seedlings from rigid containers, but stump diameter growth was significantly less than all other seedlings.

Cassia at Mirebalais -

For initial heights, all treatments except Rootrainers and Deep 5s produced measurements which differed from one another. Neg mix produced smaller initial root collar diameters than did

Haiti mix. Stumps had the greatest initial caliper, followed by Sack seedlings. The other containerized stock did not differ in initial root collar diameter measurements.

Seeds from only one sowing location had germinated and were living at the one-month survival check. Those seedlings had died at three months, and the Seed treatment was dropped from further analysis at Mirebalais. Differences attributable to nursery practice were evident at the one-month survival check (Table 4). Stumps appeared to be dead at one month, and their survival was poorer than that of any other treatment. The other difference at one month was that Sack seedlings were surviving better than Deep 5 seedlings, a difference which remained significant at three months. Stumps sprouted between one and three months, however, to the point that their survival was not different from survival of containerized seedlings. Note that the Haiti mix X Winstrip combination did not survive well, although it does not show up as different using contrast statements as they were used here.

Size and growth at three months (Table 5) are more complicated. For both measurements, Haiti mix in the nursery produced outplanted seedlings that were statistically larger and grew more than Gromix seedlings. Other mix comparisons did not differ. However, the combination Neg mix x Deep 5 produced seedlings that apparently grew more in height than the combination Gromix X Deep 5.

Stumps at three months were not as tall and did not grow as much as the containerized stock. Stump root collar diameter was

smaller than that of Sack seedlings, but not different from those of seedlings from rigid containers. For all three-month measurements, Sack seedlings were larger than Deep 5 seedlings. Sack seedlings also were larger than Rootrainer seedlings for all measurements except root collar diameter growth, which did not differ between the two treatments. Sack and Winstrip seedlings did not differ at three months.

Kapab at Cazeau -

Kapab seed was planted with the seedlings at both Cazeau and Mirebalais (Table 6). None of the kapab seed germinated, and that treatment was dropped from statistical analysis. Neither survival (Table 6), three-month height, nor growth (Table 7) was affected by nursery treatment.

For initial height (Table 6), however, Haiti mix produced taller seedlings than either Gromix or Neg mix, Sack seedlings were taller than seedlings from rigid containers, and seedlings from Winstrips were taller than those from Deep 5s. Nursery treatment also affected initial root collar diameter. Neg mix produced smaller seedlings than both Haiti and Gromix, Sacks produced the largest seedlings, and Rootrainers produced the smallest seedlings, statistically smaller than Winstrip seedlings. Both the Rootrainer and Neg mix differences were influenced by the small seedlings from that combination, however.

The other treatment effects were found with the three-month caliper measurements. Sacks produced thicker seedlings than Rootrainers or Deep 5s, but seedlings from Winstrips were not

different from Sacks. Winstrip seedlings remained significantly larger than Rootrainer seedlings.

Kapab at Mirebalais

Generally, differences due to nursery treatment were apparent among the Kapab growing at Mirebalais (Tables 6 and 7). The only variable showing no effect due to nursery treatment was height growth. Sack seedlings survived better than other treatments at both one and three months, and no other treatment was found to influence survival.

Initial height (Table 6) was greater for seedlings from Haiti mix than from Gromix or Neg mix, for seedlings from Sacks than from other containers, and for seedlings from Winstrips than from either bookplanter. Initial root collar diameter was greater on seedlings in both Gromix and Haiti mix than on those in Neg mix, was greater on those in Sacks than on those in rigid containers, and was greater in Winstrip seedlings than in Rootrainer seedlings.

At three months (Table 7), total height and root collar diameter were greater for seedlings in Haiti mix than for those in Gromix, and greater for Sack seedlings than for those in rigid containers. For growth at the root collar, however, Gromix seedlings grew less than those in either Haiti or Neg mix. Sack seedlings grew more in diameter than Winstrip or Deep 5 seedlings, but not more than Rootrainer seedlings. Growth did not differ among the three rigid containers.

Chene at Cazeau -

Direct seeding and Stumps were not tested with chene. No effect due to nursery treatment was evident for survival (Table 8), height at three months, or height or caliper growth after three months (Table 9).

Nursery treatment did affect initial measurements (Table 8). Height was less for seedlings grown in Gromix than for those in the other two mixes. Sacks produced taller seedlings than did the rigid containers, and Deep 5s produced taller seedlings than were found in Winstrips or Rootrainers.

Gromix also produced seedlings with bigger root collar diameters than did Neg mix. Caliper of seedlings from Rootrainers was smaller than those from Deep 5s, and caliper of those from rigid containers was smaller than those from Sacks. At three months, root collar diameter was smaller on seedlings from Gromix than on those from Haiti mix, and Sack seedlings were still larger than those from other containers.

Chene at Mirebalais -

More differences were apparent at Mirebalais than at Cazeau. Survival remained unaffected by nursery treatment, however (Table 8).

Haiti mix produced seedlings which were taller at outplanting than those from Gromix or Neg mix. Sacks produced taller and thicker seedlings than did other containers. No other effects on initial measurements were found.

At three months, Sack seedlings were still taller, had

greater root collar diameters, and had grown more. Rootrainer seedlings were shorter, thinner, and did not grow as much in diameter as Deep 5 seedlings. Deep 5 seedlings also had greater root collar diameters than did Winstrip seedlings at three months.

Ced at Cazeau -

Ced (Tables 10 and 11) was somewhat affected by nursery treatments. Nursery treatments did not affect survival (Table 10) or growth after outplanting (Table 11), however.

Initial height was greater in Neg mix than in Gromix, in Sacks than in rigid containers, and in Winstrips than in Rootrainers. Initial caliper was greater in Haiti mix than in Neg mix, in Sacks than in other containers, and in Winstrips than in either bookplanter. The diameter differences in Haiti mix and Winstrips may be due to the outstanding performance in that combination, however.

At three months, residual effects of nursery size differences were still evident but were beginning to diminish (Table 11). Seedlings from Sacks were still taller than those from rigid containers, but the other treatments no longer affected height. Seedlings from Sacks had larger root collar diameters, and those from Rootrainers smaller root collar diameters, than the root collar diameters on seedlings from the other two containers.

Ced at Mirebalais -

At Mirebalais, the same general effects were seen for the

initial measurements that were seen at Cazeau (Table 10). The exceptions at Mirebalais were that initial height was greater for Neg mix seedlings than for seedlings produced in Gromix or Haiti mix, and no difference was seen between root collar diameters of Rootrainer and Winstrip seedlings.

Ced survival was so uniformly poor at Mirebalais that other measurements showed no effects of nursery treatment. Only eight ced individuals survived past three months. Such low numbers of seedlings prevented large differences, which probably are biologically significant, from being statistically significant. Survival appeared best with Sacks filled with Neg mix, however. Note also that surviving seedlings grew well.

DISCUSSION

Generally, nursery effects on initial measurements of the outplanted seedlings were the same as found in the previous study (Reid 1989). If anything, more differences were statistically significant in the present study than in the nursery study. Only two instances exist where differences were not similar: chene height in Neg mix was less than in Gromix in the nursery study, but was more than in Gromix in this study; and ced root collar diameter in Winstrips was less than in bookplanters in the nursery, but was greater than in bookplanters in this study. Since so few differences exist between the nursery measurements and the initial measurements of the field study, the outplanted seedlings are considered to be representative.

Post-planting measurements usually were not significantly different among seedlings from rigid containers, and followed no pattern when they were different. Outplanted seedlings from Deep 5s outperformed those from Rootrainers on only 3 occasions. Those occasions were three-month height, caliper, and caliper growth on chene at Mirebalais. Outplanted Winstrips seedlings outperformed those from Rootrainers on two occasions, for three-month calipers of kapab and of ced at Cazeau. Only once did Winstrip seedlings performed better than those from Deep 5s, and that was for cassia three-month survival at Cazeau. Deep 5 seedlings outperformed Winstrip seedlings for three-month caliper measurements on neem at both locations, and for three-month caliper and caliper growth on chene at Mirebalais. Rootrainers never outperformed Winstrips.

Container, mix, site, and species sometimes appeared to interact and produce unexpected results. For instance, cassia produced in Winstrips filled with Haiti mix did not survive well at Mirebalais, but those seedlings which did survive grew as well as those produced in Sacks. Also with cassia at Mirebalais, seedlings from Deep 5s filled with Neg mix grew more in height than those from the Deep 5 x Gromix combination. Other combinations which seemed to have a strong effect on observed differences were: for neem caliper at Mirebalais, Neg mix in both Deep 5s and Winstrips; for kapab caliper at Cazeau, Neg mix in Rootrainers; and for ced caliper at Cazeau, Haiti mix in Winstrips. These apparent interactions might not reoccur if this

study were repeated. Of the two interactions seen in the nursery study (Reid 1989), neem from the recommended Deep 5 x Haiti mix combination was not planted, and ced from the proscribed Winstrip x Neg mix combination was not different than ced from other combinations, and had better-than-average survival at Mirebalais.

The apparent interactions seen with cassia may be due to its sensitivity to nursery treatment. All variables measured on cassia were affected by nursery treatment at planting, and still showed effects at three months. One interesting observation with cassia is that Neg mix seedlings were smaller at planting, but tended to survive better and grow more than seedlings in the other mixes.

Even a cursory reading of the preceding Results section shows the superior outplanting performance of Sack seedlings. Out of 180 comparisons of post-planting measurements, Sack seedlings were larger, had grown more, or had survived better than seedlings in rigid containers for 76 of them, or 42% of the cases. In contrast, seedlings from rigid containers were never larger than Sack seedlings. The excellent performance of seedlings produced in Sacks was noted in a preceding study (Reid 1989). Two possible explanations for Sack seedlings' performance will be discussed here: the increased mix volume, and the protective sack.

First, consider the protection provided by the Sack. With the rigid containers used in the AOP, the seedling is removed from the container before it leaves the nursery. Although care

is taken not to disturb the roots during transport and planting, jostling of the root ball and soil moisture loss does occur. With a Sack, the root ball remains undisturbed until the moment it is placed in the hole; only then is the Sack removed. If the protection due to the Sack is the primary reason for the seedling's better performance, then that effect should carry over to Sacks with smaller volumes.

Second, seedlings are usually larger when their soil volume is larger, and larger seedlings often survive better in a hostile environment (Tinus and McDonald 1979). Thus, part of the explanation for the superior Sack performance undoubtedly relates to their large volume. The troublesome aspect of this explanation is that if increasing rooting volume also increases growth and survival, then seedlings grown in Deep 5s should outperform those from Rootrainers, something that happened in this study only for chene at Mirebalais. The volume difference between Rootrainers and Deep 5s may not be large enough to produce readily detectable differences in survival and growth. However, informal observations by field people suggest differences do exist. If differences exist, a study employing enough individual seedlings should show those differences.

Besides producing a larger seedling, one advantage often cited about Deep 5s is that the longer root plug places roots deeper in the soil than does the Rootrainer. This characteristic benefits the seedling by enabling it to take up sub-surface water and therefore to better survive drought. This advantage would

quickly disappear if the Deep 5 seedling were planted shallowly or if the Rootrainer seedling were planted deeply. Getting planters to dig holes deeper than the root plugs are long will be a challenge. Nevertheless, a study to test this effect of planting depth needs to be discussed and carried out.

Short-term survival and growth are not the only considerations when choosing a container. Windfirmness, or the ability of a tree not to uproot when stressed with high winds, is often cited as a potential problem with containerized tree seedlings (Tinus and McDonald 1979). Anecdotal evidence in Haiti suggests trees produced in Sacks have been uprooted and blown over, while those of the same species produced in rigid containers were broken off in the same storm. The seriousness of the blow-down problem - the susceptability of pole-sized trees to blowdown, the magnitude of loss associated with blowdowns - is not known.

Unfortunately, most of the seed tested in the Seeding technique failed to emerge. This failure should not be taken as a condemnation of direct seeding; successful hedgerow establishment throughout Haiti attests to its viability. Hopefully, enough individuals have survived that future comparisons can be made between growth of trees from containers and trees from seed. However, to compare these techniques correctly, direct-seeded trees ought to be treated in the field as they would be for the first months in the nursery.

Current methods of producing Stumps are adequate, but can be

improved. Planter resistance will be a bigger challenge than anything faced in the nursery, however. Along with everyone else, I had realized getting people to plant Stumps would take a lot of good extension work, but I did not realize how much until the following occurrance at Mirebalais. At planting, I showed the Stumps to the workers there, explaining that they were something new that we were trying. They seemed to accept the idea, or at least were willing to let someone else do the work of testing it without ridiculing him openly. When I came back for the one-month survival check, however, they told me that Stumps were no good. (Indeed, they did not sprout immedidately at Mirebalais like they had at ODH.) While I made the survival tally, I was followed by the oldest son of the caretaker of the demonstration site, a boy of about 13. At one point, before I could stop him, he reached down and pulled a cassia Stump out of the ground, saying "Gade, sa pa bon." Granted, he was a child, but the child of someone who works in a demonstration area would probably be more open to new techniques than would the average peasant. When he does not have the patience to let a Stump take root, I fear for the Stump planted elsewhere. (That particular cassia, which had not yet formed roots then, was replanted and two months later had a healthy new leader that was topped during the 18 August weeding.)

In many ways, this study can be considered preliminary. It was rather large and so appears to be the last experiment that will need to be carried out, but it was large to include all the

production methods. Important differences are apparent, however. Additional information which can be extracted from these data sets include the numbers of individuals per treatment combination needed to properly conduct future studies, and the relationship between certain destructive measurements (e.g., root:shoot ratio) and field growth and survival.

CONCLUSIONS

1. Field differences due to planting mix have been trivial and very specific. Other than these specific instances, the mix effects will probably disappear at the six-month measurements.

2. All evidence collected in the preparation of this and the previous report (Reid 1989) indicates that no significant biological difference exists between Deep 5s and Rootrainers. If statistically significant differences are ever consistently found, they will probably not be biologically important.

3. The black plastic Sacks used in this study produced seedlings which were bigger at planting, survived better, and grew more than seedlings produced in rigid containers. These differences probably are due to the Sack's large soil volume.

RECOMMENDATIONS

1. The 265 ml black plastic Sacks used in this study should be tested against small plastic Sacks, similar in size to those CARE is considering using in their nurseries, in an outplanting study similar to this one. Such a study would determine if the Sack's

performance is due to its larger volume or its increased protection of the root plug during transport.

2. Standard Rootrainers and Deep 5s should be tested in an outplanting study which uses many individuals from each container on many different sites. Only after this is done can Rootrainers and Deep 5s be said to not be different.

3. If the bottom of a Rootrainer plug and the bottom of a Deep 5 plug were planted at the same depth, seedling growth and survival might not differ. This hypothesis also needs to be tested.

Table 1. Tree species and regeneration techniques evaluated for growth and survival after outplanting.

Species	Container with			Other Method
	Gromix	Haiti mix	Neg mix	
neem	Rootrainer Winstrip Deep 5 Sack	Rootrainer Winstrip	Rootrainer Winstrip Deep 5 Sack	Direct Seed Stump
cassia	Rootrainer Winstrip Deep 5	Rootrainer Winstrip Deep 5 Sack	Deep 5 Sack	Direct Seed Stump
kapab	Winstrip Deep 5 Sack	Rootrainer Winstrip	Rootrainer Deep 5 Sack	Seed
chene	Rootrainer Winstrip Deep 5 Sack	Rootrainer Winstrip Deep 5	Deep 5 Sack	-
ced	Sack	Rootrainer Winstrip Deep 5	Rootrainer Winstrip Deep 5 Sack	-

Table 2. Neem (Azidirachta indica) initial measurements and survival results. See text for details.

treatment combination	initial height - cm -	initial caliper - mm -	1-month survivl - % -	3-month survivl - % -
		ODH		
Seed	.	.	8c	8b
Stump	11.7	7.41	82b	82a
Gro-Rtr	7.6	2.88	95a	85a
Gro-Wsp	8.7	3.33	100a	100a
Gro-Dp5	9.4	2.95	90a	84a
Gro-Sac	15.6	5.50	100a	100a
Hti-Rtr	8.2	3.11	100a	94a
Hti-Wsp	7.0	2.67	100a	89a
Neg-Rtr	6.6	2.60	100a	100a
Neg-Wsp	5.6	2.37	100a	100a
Neg-Dp5	8.7	2.83	100a	94a
Neg-Sac	10.7	3.44	89a	89a
		Mirebalais		
Stump	6.5	8.18	5b	21b
Gro-Rtr	9.3	3.12	83a	67a
Gro-Wsp	7.4	2.86	86a	71a
Gro-Dp5	9.7	3.29	92a	75a
Gro-Sac	15.4	5.50	100a	100a
Hti-Rtr	7.9	2.91	100a	82a
Hti-Wsp	8.0	3.29	100a	86a
Neg-Rtr	8.3	2.73	77a	62a
Neg-Wsp	6.2	2.44	87a	75a
Neg-Dp5	9.9	3.29	75a	58a
Neg-Sac	9.9	3.43	100a	71a

Table 3. Neem (Azidirachta indica) three-month measurements and growth results. See text for details.

treatment combination	3-month height - cm -	3-month caliper - mm -	1st quarter growth height - cm -	1st quarter growth caliper - mm -
- - - -		ODH		- - - -
Seed	14.0	2.25	14.0	2.25d
Stump	41.2a	7.94	29.2a	0.47c
Gro-Rtr	44.0a	6.08	36.1a	3.14b
Gro-Wsp	38.3a	5.22	29.7a	1.89b
Gro-Dp5	45.8a	6.75	39.2a	3.66ab
Gro-Sac	55.4a	9.77	39.8a	4.27a
Hti-Rtr	44.5a	6.23	36.1a	3.09b
Hti-Wsp	50.0a	6.25	43.0a	3.50b
Neg-Rtr	45.2a	5.90	38.6a	3.30b
Neg-Wsp	38.2a	5.00	32.6a	2.62b
Neg-Dp5	55.6a	7.29	46.8a	4.47ab
Neg-Sac	60.4a	8.75	49.9a	5.31a
- - - -		Mirebalais		- - - -
Stump	19.0b	7.75	12.6b	-0.75c
Gro-Rtr	33.9b	4.31	24.6b	1.06b
Gro-Wsp	23.0b	4.40	15.7b	1.60b
Gro-Dp5	26.1b	4.56	16.5b	1.22b
Gro-Sac	55.9a	8.30	51.7a	2.80a
Hti-Rtr	19.0b	3.61	14.9b	0.67b
Hti-Wsp	22.7b	4.50	17.6b	1.17b
Neg-Rtr	32.9b	5.00	29.0b	2.12b
Neg-Wsp	19.8b	3.08	13.8b	0.67b
Neg-Dp5	34.4b	5.64	29.2b	2.36b
Neg-Sac	40.6a	6.70	30.9a	3.10a

Table 4. Cassia (Cassia siamea) initial measurements and survival results. See text for details.

treatment combination	initial height - cm -	initial caliper - mm -	1-month survivl - % -	3-month survivl - % -
- - - -		ODH		- - - -
Seed	.	.	16	16
Stump	10.5	7.21	96a	87
Gro-Rtr	11.1	2.66	95a	95
Gro-Wsp	13.9	2.75	100a	91
Gro-Dp5	10.2	2.37	95a	75
Hti-Rtr	8.6	2.40	100a	80
Hti-Wsp	10.3	2.82	100a	100
Hti-Dp5	8.9	2.48	95a	75
Hti-Sac	17.8	3.98	100a	100
Neg-Dp5	8.2	2.28	100a	100
Neg-Sac	15.2	3.28	95a	100
- - - -		Mirebalais		- - - -
Seed	.	.	0	.
Stump	8.1	6.94a	25	56
Gro-Rtr	11.3	2.50c	73	64
Gro-Wsp	14.5	2.72c	100	89
Gro-Dp5	11.9	2.00c	50	50
Hti-Rtr	9.5	2.20c	67	58
Hti-Wsp	12.7	2.83c	42	25
Hti-Dp5	10.6	2.71c	58	58
Hti-Sac	19.8	4.10b	82	82
Neg-Dp5	9.4	2.33c	42	42
Neg-Sac	15.7	3.15b	85	85

Table 5. Cassia (Cassia siamea) three-month measurements and growth results. Values followed by the same letter are not different (α=0.05). See text for values without letters.

treatment combination	3-month height - cm -	3-month caliper - mm -	1st quarter growth height - cm -	1st quarter growth caliper - mm -
- - - -		ODH		- - - -
Seed	11.7c	1.62c	11.7b	1.62bc
Stump	36.6b	7.95b	26.1b	0.60c
Gro-Rtr	33.6b	6.22b	24.0b	3.58b
Gro-Wsp	35.1b	6.35b	21.1b	3.58b
Gro-Dp5	36.9b	6.57b	26.7b	4.20b
Hti-Rtr	31.9b	5.67b	23.2b	3.28b
Hti-Wsp	41.9b	7.45b	31.6b	4.63b
Hti-Dp5	41.2b	7.31b	32.1b	4.75b
Hti-Sac	62.3a	10.88a	44.5a	6.90a
Neg-Dp5	40.8b	6.92b	32.6b	4.64b
Neg-Sac	53.1a	9.55a	39.9a	6.28a
- - - - -		Mirebalais		- - - - -
Stump	18.3	8.11	8.6	0.89
Gro-Rtr	39.4	6.71	27.5	4.07
Gro-Wsp	44.4	7.50	29.4	4.75
Gro-Dp5	35.0	5.75	23.3	3.83
Hti-Rtr	61.1	9.86	51.5	7.43
Hti-Wsp	83.0	11.33	70.0	8.17
Hti-Dp5	56.6	8.50	45.7	5.79
Hti-Sac	70.4	11.17	50.2	6.72
Neg-Dp5	62.0	9.20	53.5	6.90
Neg-Sac	79.6	12.23	64.0	9.00

Table 6. Kapab (Colubrina arborescens) initial measurements and survival results. Values followed by the same letter are not different (α=0.05). See text for values without letters.

treatment combination	initial height - cm -	initial caliper - mm -	1-month survival - % -	3-month survival - % -
- - - -		ODH		- - - -
Seed	.	.	0	.
Gro-Wsp	11.8	3.08	100a	65a
Gro-Dp5	8.9	2.89	89a	61a
Gro-Sac	16.3	3.87	95a	84a
Hti-Rtr	11.9	2.95	84a	58a
Hti-Wsp	12.4	2.87	95a	85a
Neg-Rtr	9.5	2.15	80a	70a
Neg-Dp5	9.9	2.79	100a	76a
Neg-Sac	19.3	3.58	90a	80a
- - - -		Mirebalais		- - - -
Seed	.	.	0	.
Gro-Wsp	12.4	2.83	50b	50b
Gro-Dp5	8.7	2.58	83b	67b
Gro-Sac	19.9	3.83	100a	100a
Hti-Rtr	11.8	2.50	58b	50b
Hti-Wsp	13.6	2.78	80b	67b
Neg-Rtr	8.7	1.96	67b	42b
Neg-Dp5	10.2	2.46	55b	46b
Neg-Sac	19.4	3.08	100a	92a

Table 7. Kapab (Colubrina arborescens) three-month measurements and growth results. Values followed by the same letter are not different (α=0.05). See text for values without letters.

treatment combination	3-month height - cm -	3-month caliper - mm -	1st quarter growth height - cm -	1st quarter growth caliper - mm -
- - - -		ODH		- - - -
Gro-Wsp	30.4a	5.15ab	18.8a	1.92a
Gro-Dp5	26.9a	4.79bc	18.0a	1.96a
Gro-Sac	35.1a	5.78a	18.2a	1.78a
Hti-Rtr	25.0a	4.18c	15.7a	1.14a
Hti-Wsp	30.0a	5.41ab	19.1a	2.47a
Neg-Rtr	27.9a	4.30c	17.9a	2.13a
Neg-Dp5	28.7a	4.59bc	18.6a	1.69a
Neg-Sac	32.1a	5.75a	15.9a	2.17a
- - - -		Mirebalais		- - - -
Gro-Wsp	40.2	5.75	26.6a	2.83
Gro-Dp5	47.5	6.44	44.5a	3.69
Gro-Sac	78.6	9.71	58.7a	5.87
Hti-Rtr	59.2	7.83	46.4a	5.00
Hti-Wsp	64.8	8.08	50.6a	5.08
Neg-Rtr	59.0	7.60	49.9a	5.40
Neg-Dp5	59.4	7.70	47.5a	4.80
Neg-Sac	74.0	9.00	54.6a	5.82

Table 8. Chene (Catalpa longissima) initial measurements and survival results. Values followed by the same letter are not different (α=0.05). See text for values without letters.

treatment combination	initial height - cm -	initial caliper - mm -	1-month survivl - % -	3-month survivl - % -
- - - -		ODH		- - - -
Gro-Rtr	11.1	2.25	95a	75a
Gro-Wsp	10.5	2.47	90a	79a
Gro-Dp5	12.5	2.67	95a	85a
Gro-Sac	28.2	4.20	80a	95a
Hti-Rtr	13.6	2.38	95a	80a
Hti-Wsp	15.7	2.62	95a	85a
Hti-Dp5	17.0	2.64	95a	81a
Neg-Dp5	16.3	2.58	94a	83a
Neg-Sac	19.4	3.12	100a	95a
- - - -		Mirebalais		- - - -
Gro-Rtr	14.0	2.42b	67a	50a
Gro-Wsp	9.2	2.17b	67a	50a
Gro-Dp5	10.6	2.42b	58a	42a
Gro-Sac	26.7	3.92a	83a	75a
Hti-Rtr	13.9	2.21b	50a	42a
Hti-Wsp	15.8	2.42b	85a	46a
Hti-Dp5	18.2	2.77b	55a	55a
Neg-Dp5	14.3	2.46b	67a	58a
Neg-Sac	19.4	3.08a	83a	83a

Table 9. Chene (Catalpa longissima) three-month measurements and growth results. Values followed by the same letter are not different (α=0.05). See text for values without letters.

treatment combination	3-month height - cm -	3-month caliper - mm -	1st quarter growth height - cm -	1st quarter growth caliper - mm -
- - - -		ODH		- - - -
Gro-Rtr	40.2a	5.97	29.0a	3.57a
Gro-Wsp	39.3a	5.96	28.7a	3.43a
Gro-Dp5	39.3a	6.15	26.8a	3.41a
Gro-Sac	50.7a	8.71	25.3a	4.50a
Hti-Rtr	46.9a	6.88	32.9a	4.41a
Hti-Wsp	48.2a	8.00	34.3a	5.21a
Hti-Dp5	44.6a	6.68	27.1a	3.91a
Neg-Dp5	38.9a	5.90	21.9a	3.23a
Neg-Sac	49.2a	7.71	29.2a	4.63a
- - - - -		Mirebalais	- - - - -	
Gro-Rtr	24.2	5.00c	19.0b	2.42
Gro-Wsp	36.7	4.75c	27.7b	2.58
Gro-Dp5	45.0	6.30b	32.5b	3.20
Gro-Sac	74.1	11.44a	56.4a	7.22
Hti-Rtr	33.2	4.90c	16.6b	2.50
Hti-Wsp	46.5	6.25c	35.5b	3.42
Hti-Dp5	46.2	7.08b	26.1b	3.83
Neg-Dp5	54.9	7.93b	38.4b	4.93
Neg-Sac	73.2	10.10a	53.3a	6.95

Table 10. Ced (Cedrela odorata) initial measurements and survival results. Values followed by the same letter are not different (α=0.05). See text for values without letters.

treatment combination	initial height - cm -	initial caliper - mm -	1-month survival - % -	3-month survival - % -
- - - - -		ODH	- - - - -	
Gro-Sac	12.1	5.15	90a	60a
Hti-Rtr	6.4	2.90	60a	20a
Hti-Wsp	10.9	4.60	100a	70a
Hti-Dp5	7.3	2.83	67a	44a
Neg-Rtr	7.1	2.94	89a	44a
Neg-Wsp	7.6	2.95	70a	40a
Neg-Dp5	8.1	2.75	80a	40a
Neg-Sac	16.0	4.50	100a	80a
- - - - -		Mirebalais	- - - - -	
Gro-Sac	14.0	4.57	29a	29a
Hti-Rtr	7.4	2.71	14a	14a
Hti-Wsp	13.9	4.21	29a	0a
Hti-Dp5	7.6	1.79	14a	0a
Neg-Rtr	6.2	2.21	14a	14a
Neg-Wsp	5.3	1.71	29a	14a
Neg-Dp5	8.7	2.14	0a	0a
Neg-Sac	18.2	4.36	71a	43a

Table 11. Ced (Cedrela odorata) three-month measurements and growth results. Values followed by the same letter are not different (α=0.05).

treatment combination	3-month height - cm -	3-month caliper - mm -	1st quarter growth height - cm -	1st quarter growth caliper - mm -
- - - - -		ODH		- - - -
Gro-Sac	25.3a	8.14a	11.4a	2.43a
Hti-Rtr	11.3b	3.83c	7.0a	1.17a
Hti-Wsp	16.1b	6.79b	5.7a	2.29a
Hti-Dp5	18.7b	5.62b	10.8a	2.62a
Neg-Rtr	13.5b	4.00c	6.0a	1.00a
Neg-Wsp	15.2b	5.50b	8.5a	2.25a
Neg-Dp5	13.2b	6.25b	5.0a	3.00a
Neg-Sac	24.5a	7.75a	8.6a	3.00a
- - - - -		Mirebalais		- - - -
Gro-Sac	42.0a	11.50a	27.5a	5.25a
Hti-Rtr	34.0a	5.00a	23.5a	0.00a
Hti-Wsp	.	.	.	.
Hti-Dp5	.	.	.	.
Neg-Rtr	16.0a	6.50a	11.0a	4.00a
Neg-Wsp	25.0a	4.00a	21.0a	1.50a
Neg-Dp5	.	.	.	.
Neg-Sac	68.0a	13.33a	47.0a	9.00a

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APPENDIX

Poor Portion of Site at Mirebalais

Means for Neem on poor site at Mirebalais

treatment combination	initial height - cm -	initial caliper - mm -	1-month survival - % -	3-month survival - % -
Stump	6.4b	8.88	25b	25a
Gro-Rtr	8.1b	2.83	67a	67a
Gro-Wsp	7.1b	2.50	75a	75a
Gro-Dp5	9.2b	3.44	100a	100a
Gro-Sac	15.5a	6.17	100a	100a
Hti-Rtr	7.2b	3.08	100a	83a
Hti-Wsp	9.5b	4.00	100a	100a
Neg-Rtr	9.6b	2.40	60a	40a
Neg-Wsp	6.8b	2.50	80a	60a
Neg-Dp5	9.6b	3.14	100a	71a
Neg-Sac	11.8a	4.00	100a	67a

Values followed by the same letter are not different (α=0.05)

Means for Neem on poor site at Mirebalais (continued)

treatment combination	3-month height - cm -	3-month caliper - mm -	1st quarter growth height - cm -	1st quarter growth caliper - mm -
Stump	39.0b	9.00a	31.5b	0.00b
Gro-Rtr	31.0b	4.75b	22.7b	1.50b
Gro-Wsp	21.7b	4.17b	14.3b	1.50b
Gro-Dp5	20.1b	4.21b	10.9b	0.86b
Gro-Sac	76.0a	10.50a	60.5a	4.30a
Hti-Rtr	10.4b	2.70b	4.6b	-0.40b
Hti-Wsp	8.0b	7.00b	0.0b	3.00b
Neg-Rtr	23.5b	4.50b	13.7b	1.75b
Neg-Wsp	22.3b	3.67b	15.7b	1.67b
Neg-Dp5	36.4b	5.70b	34.2b	2.70b
Neg-Sac	57.0a	7.50a	45.2a	3.25a

Values followed by the same letter are not different (α=0.05)

ANOVA for Neem on poor site at Mirebalais

Variable	Source	df	MS	F	prob>F
1-month survival	treatment	10	0.253	2.305	0.031
	Gro-Haiti	1	0.194	1.773	0.191
	Haiti-Neg	1	0.230	2.096	0.156
	Gro-Neg	1	0.000	0.001	0.971
	Rtr-Wst	1	0.037	0.341	0.563
	Rtr-Dp5	1	0.413	3.765	0.060
	Wst-Dp5	1	0.099	0.900	0.349
	Sac-Rtr	1	0.244	2.229	0.144
	Sac-Wst	1	0.069	0.626	0.434
	Sac-Dp5	1	0.000	0.000	1.000
	Stmp-rigid	1	1.260	11.488	0.002
	Stmp-Sac	1	1.350	12.312	0.001
	error	38	0.110	-	
3-month survival	treatment	10	0.250	1.270	0.281
	error	38	0.197	-	
3-month height	treatment	10	1164.129	5.365	0.000
	Gro-Haiti	1	577.478	2.661	0.116
	Haiti-Neg	1	370.125	1.706	0.204
	Gro-Neg	1	32.257	0.149	0.703
	Rtr-Wst	1	58.050	0.268	0.610
	Rtr-Dp5	1	201.163	0.927	0.346
	Wst-Dp5	1	441.647	2.035	0.167
	Sac-Rtr	1	5891.759	27.150	0.000
	Sac-Wst	1	6142.941	28.308	0.000
	Sac-Dp5	1	4970.024	22.903	0.000
	Stmp-rigid	1	285.645	1.316	0.263
	Stmp-Sac	1	625.862	2.884	0.103
	error	23	217.004	-	
3-month caliper	treatment	10	16.345	10.447	0.000
	Gro-Haiti	1	0.302	0.193	0.665
	Haiti-Neg	1	1.156	0.739	0.399
	Gro-Neg	1	1.803	1.153	0.294
	Rtr-Wst	1	2.900	1.854	0.187
	Rtr-Dp5	1	4.329	2.767	0.110
	Wst-Dp5	1	0.001	0.000	0.985
	Sac-Rtr	1	73.659	47.077	0.000
	Sac-Wst	1	41.796	26.713	0.000
	Sac-Dp5	1	55.585	35.526	0.000
	Stmp-rigid	1	18.543	11.851	0.002
	Stmp-Sac	1	0.000	0.000	1.000
	error	23	1.565	-	

ANOVA for Neem on poor site at Mirebalais (cont.)

Variable	Source	df	MS	F	prob>F
3-month height growth	treatment	10	920.094	5.149	0.001
	Gro-Haiti	1	505.701	2.830	0.107
	Haiti-Neg	1	295.021	1.651	0.213
	Gro-Neg	1	0.057	0.000	0.986
	Rtr-Wst	1	42.434	0.237	0.631
	Rtr-Dp5	1	332.646	1.862	0.187
	Wst-Dp5	1	559.246	3.130	0.091
	Sac-Rtr	1	4418.000	24.725	0.000
	Sac-Wst	1	4671.357	26.143	0.000
	Sac-Dp5	1	2992.111	16.745	0.001
	Stmp-rigid	1	273.565	1.531	0.230
	Stmp-Sac	1	378.116	2.116	0.161
	error	21	178.684	-	
3-month caliper growth	treatment	10	6.295	6.177	0.000
	Gro-Haiti	1	0.079	0.077	0.784
	Haiti-Neg	1	0.049	0.048	0.828
	Gro-Neg	1	0.161	0.158	0.695
	Rtr-Wst	1	2.768	2.716	0.113
	Rtr-Dp5	1	3.134	3.075	0.093
	Wst-Dp5	1	0.045	0.044	0.836
	Sac-Rtr	1	23.634	23.190	0.000
	Sac-Wst	1	9.200	9.028	0.006
	Sac-Dp5	1	13.782	13.523	0.001
	Stmp-rigid	1	2.169	2.128	0.158
	Stmp-Sac	1	11.898	11.674	0.002
	error	23	1.019	-	

Means for Cassia on poor site at Mirebalais

treatment combination	initial height - cm -	initial caliper - mm -	1-month survival - % -	3-month survival - % -
Seed	.	.	0	.
Stump	11.2b	7.70a	40a	60a
Gro-Rtr	11.1b	2.57c	71a	57a
Gro-Wsp	14.0ab	2.50c	100a	100a
Gro-Dp5	12.2b	2.00c	33a	33a
Hti-Rtr	10.3b	2.25c	50a	50a
Hti-Wsp	12.8ab	2.50c	0a	0a
Hti-Dp5	9.8b	2.70c	20a	20b
Hti-Sac	18.5a	4.17b	67a	67a
Neg-Dp5	10.1b	2.21c	29a	29a
Neg-Sac	14.5a	2.88b	75a	75a

Values followed by the same letter are not different (α=0.05)

Means for Cassia on poor site at Mirebalais (Cont.)

treatment combination	3-month height - cm -	3-month caliper - mm -	1st quarter growth height - cm -	1st quarter growth caliper - mm -
Seed	.	.	.	.
Stump	21.7a	7.83a	14.3a	1.33a
Gro-Rtr	30.7a	6.00a	19.6a	3.25a
Gro-Wsp	27.0a	4.50a	13.0a	2.00a
Gro-Dp5	31.5a	5.00a	19.0a	3.25a
Hti-Rtr	44.0a	7.50a	33.0a	5.00a
Hti-Wsp	.	.	.	.
Hti-Dp5	25.0a	4.50a	16.5a	2.50a
Hti-Sac	53.5a	9.75a	34.5a	4.87a
Neg-Dp5	44.0a	6.25a	34.0a	4.50a
Neg-Sac	70.0a	12.67a	57.0a	9.83a

Values followed by the same letter are not different (α=0.05)

ANOVA for Cassia on poor site at Mirebalais

Variable	Source	df	MS	F	prob>F
1-month survival	treatment	9	0.270	1.075	0.405
	error	35	0.251	-	
3-month survival	treatment	9	0.238	0.191	0.521
	error	35	0.259	-	
3-month height	treatment	8	668.612	1.370	0.300
	error	12	487.910	-	
3-month caliper	treatment	8	17.697	2.478	0.076
	error	12	7.142	-	
3-month height growth	treatment	8	492.116	1.117	0.421
	error	11	440.392	-	
3-month caliper growth	treatment	8	16.909	2.138	0.114
	error	12	7.908	-	

Means for Kapab on poor site at Mirebalais

treatment combination	initial height - cm -	initial caliper - mm -	1-month survivl - % -	3-month survivl - % -
Seed	.	.	0	.
Gro-Wsp	12.4	2.86	43a	43a
Gro-Dp5	8.5	2.38	50a	25a
Gro-Sac	24.0	4.00	100a	100a
Hti-Rtr	11.9	2.50	50a	40a
Hti-Wsp	12.9	2.63	75a	50a
Neg-Rtr	9.0	1.86	57a	14a
Neg-Dp5	11.2	2.71	57a	57a
Neg-Sac	18.4	2.90	100a	80a

treatment combination	3-month height - cm -	3-month caliper - mm -	1st quarter growth height - cm -	1st quarter growth caliper - mm -
Gro-Wsp	42.0a	6.67a	27.7a	3.50a
Gro-Dp5	23.0a	4.50a	14.5a	1.50a
Gro-Sac	29.0a	6.00a	5.0a	2.00a
Hti-Rtr	50.0a	7.37a	36.6a	4.37a
Hti-Wsp	48.5a	6.50a	35.0a	3.50a
Neg-Rtr	51.0a	7.00a	42.5a	5.00a
Neg-Dp5	63.0a	8.00a	51.2a	5.12a
Neg-Sac	56.0a	7.88a	37.8a	4.75a

Values followed by the same letter are not different (α=0.05)

ANOVA for Kapab on Poor site at Mirebalais

Variable	Source	df	MS	F	prob>F
1-month survival	treatment	7	0.201	0.792	0.599
	error	37	0.254	-	
3-month survival	treatment	7	0.268	1.073	0.400
	error	37	0.250	-	
3-month height	treatment	7	312.471	0.845	0.572
	error	12	369.708	-	
3-month caliper	treatment	7	2.157	0.517	0.805
	error	12	4.170	-	
3-month height growth	treatment	7	374.226	1.159	0.392
	error	12	322.780	-	
3-month caliper growth	treatment	7	2.846	0.811	0.595
	error	12	3.510	-	

Means for Chene on poor site at Mirebalais

treatment combination	initial height - cm -	initial caliper - mm -	1-month survivl - % -	3-month survivl - % -
Gro-Rtr	14.7a	2.42a	67a	50a
Gro-Wsp	9.8a	2.25a	25a	25a
Gro-Dp5	11.8a	2.62a	50a	50a
Gro-Sac	20.7a	3.50a	50a	50a
Hti-Rtr	13.1a	2.00a	40a	40a
Hti-Wsp	14.0a	2.08a	83a	0a
Hti-Dp5	19.0a	2.79a	57a	57a
Neg-Dp5	14.9a	2.43a	57a	57a
Neg-Sac	17.8a	2.83a	67a	67a

treatment combination	3-month height - cm -	3-month caliper - mm -	1st quarter growth height - cm -	1st quarter growth caliper - mm -
Gro-Rtr	25.0a	5.50b	20.5a	2.50a
Gro-Wsp	33.0a	5.00b	29.5a	2.50a
Gro-Dp5	39.5a	5.75b	23.7a	1.75a
Gro-Sac	77.0a	10.00a	57.5a	6.00a
Hti-Rtr	24.0a	4.00b	8.3a	2.00a
Hti-Wsp	.	.	.	.
Hti-Dp5	33.5a	5.88b	12.4a	2.63a
Neg-Dp5	47.5a	7.75b	29.1a	4.50a
Neg-Sac	46.0a	9.50a	28.3a	6.75a

Values followed by the same letter are not different (α=0.05)

ANOVA for Chene on poor site at Mirebalais

Variable	Source	df	MS	F	prob>F
1-month survival	treatment	8	0.135	0.488	0.856
	error	35	0.277	-	
3-month survival	treatment	8	0.219	0.847	0.569
	error	35	0.258	-	
3-month height	treatment	7	426.876	1.907	0.165
	error	11	223.864	-	
3-month caliper	treatment	7	8.126	3.639	0.024
	Gro-Haiti	1	1.194	0.535	0.480
	Haiti-Neg	1	7.031	3.149	0.104
	Gro-Neg	1	1.000	0.448	0.517
	Rtr-Wst	1	0.052	0.023	0.882
	Rtr-Dp5	1	9.136	4.091	0.068
	Wst-Dp5	1	1.914	0.857	0.374
	Sac-Rtr	1	42.857	19.193	0.001
	Sac-Wst	1	16.409	7.349	0.020
	Sac-Dp5	1	22.289	9.982	0.009
	error	11	2.233	-	
3-month height growth	treatment	7	333.998	2.716	0.074
	error	10	122.975	-	
3-month caliper growth	treatment	7	7.001	2.757	0.062
	error	11	2.540	-	